

Mission Technology Forum

## Section 9

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### ALI Lessons Learned

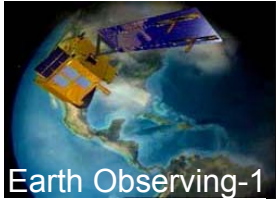
*This work was sponsored by NASA Goddard Space flight Center under U.S. Air Force Contract number F19628-00-C-0002. Opinions, interpretations, conclusions and recommendations are those of the author and are not necessarily endorsed by the United States Government.*



08/15-16/01

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# *Topics of Discussion*

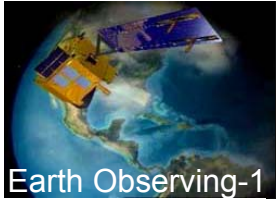


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- ◆ *Programmatic Issues*
- ◆ *Technical Issues*
- ◆ *Summary*



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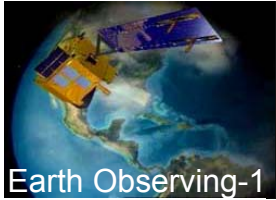


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## ***Programmatic Issues***



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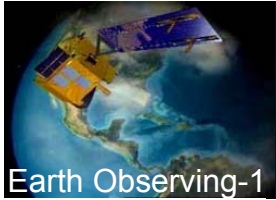
# *Programmatic (1 of 3)*



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- ◆ ***Issue: The Grating Imaging Spectrometer (GIS) was added to ALI, three months after program start.***
  - ***The GIS integration complexity and cost and schedule impact were underestimated and ultimately led to the elimination of both the GIS and the Wedge Imaging Spectrometer (WIS).***
- ◆ ***Lesson: Mission changes should be considered very carefully***





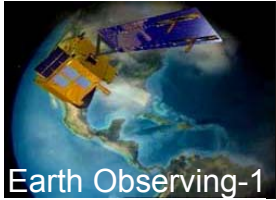
# Programmatic (2 of 3)



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- ◆ ***Issue: The spacecraft structure was changed from composite to aluminum ten (10) months after program start (February 26, 1997) requiring substantial redesign of ALI structures.***
  - *The launch vehicle was changed from the Taurus to Delta 2 (January 28, 1997) increasing mass allocations.*
  - *The Project Office traded spacecraft mass for cost and decided to switch from composite to aluminum structure.*
  - *The impact of the resulting ALI redesign was not fully appreciated.*
- ◆ ***Lesson: Requirements and interfaces need to be frozen early in the design process.***





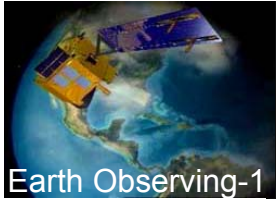
# Programmatic (3 of 3)



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- ◆ ***Issue: The decision was made to build all electronics assemblies without Engineering Development Units (EDU) or Qualification Units to “reduce cost”.***
  - ***This delayed problem discovery which made correction more difficult and more, not less, expensive.***
- ◆ ***Lesson: The EDU serves a useful purpose and should not be skipped.***
- ◆ ***Issue: The mandated 10% reserve proved inadequate for a program for flight-validation of new technologies.***
  - ***The new technologies incorporated in ALI required further development to produce flight hardware.***
- ◆ ***Lesson: Adequate reserves should be provided (e.g., 30%), commensurate with technology readiness, to resolve unanticipated problems and to pursue back-up options.***



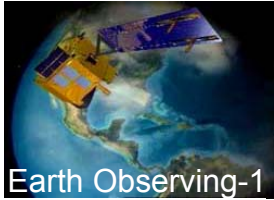


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## ***Technical Issues***



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# Focal Plane Contamination

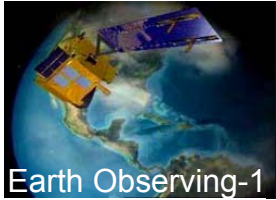


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- ◆ ***Issue : Contamination accumulates over time on the ALI focal plane filters. The contaminants are boiled off through periodic bake-outs on-orbit, every 10 days, lasting 20 hours.***
  - *While the focal plane is warmed up, the VNIR data are still good, however, the SWIR data are not.*
  - *Contamination is no longer present in the SWIR bands.*
  - *Almost all materials used on ALI met NASA outgassing specifications including the Z-306 black paint.*
  - *All components were baked out. Cost and schedule sometimes drove bake-out duration decisions.*
- ◆ ***Lesson : Need uniformity across the board for baking out components to minimize contamination potential in vacuum testing and on orbit.***







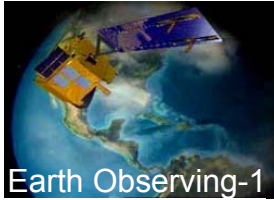
# Leaky Detectors



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- ◆ ***Issue : Two ALI detectors (pixels), out of a total of 15,360, are coupling their signal to the neighboring detectors creating streaks in the images.***
  - *The problem was not evident in the original test data (flood illumination of focal plane detectors).*
  - *Special algorithms have been developed that greatly reduce the effects of leakage, virtually eliminating it.*
- ◆ ***Lesson : Future Sensor Chip Assemblies should be screened to eliminate any that have leaky detectors.***





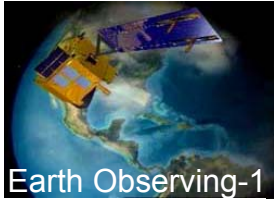
# Vacuum Chamber Window Effects



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- ◆ ***Issue : During optical calibration under thermal-vacuum, it appeared that the focus of the instrument had shifted.***
  - *It was determined both experimentally and analytically, that the focus shift was due to the chamber window distortion due to the temperature gradient.*
  - *A technique was developed to eliminate this effect.*
- ◆ ***Lesson : Understand all optical effects of thermal-vacuum chamber windows and address them in the test plan and test procedures.***





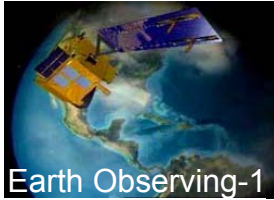
# Other Technical Issues (1 of 4)



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- ◆ ***Instrument Alignment on S/C***
  - ***Issue: ALI and Hyperion were not co-aligned.***
    - *Each instrument's alignment relative to the S/C was carefully measured and recorded.*
- ◆ ***Instrument Pointing***
  - ***Issue: It took several weeks to establish accurate instrument pointing on-orbit.***
    - *S/C pointing was well established.*
  - ***Common Lesson: Need a System Engineer to oversee and correct critical performance issues at the system level.***





# Other Technical Issues (2 of 4)



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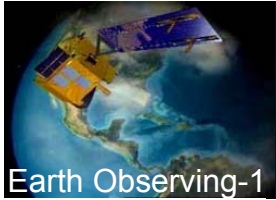
## ◆ *Internal Lamps*

- *Issue: The brightness of the lamps changed on-orbit (increased).*
  - *Filaments run hotter in zero-G because of the absence of gas convection.*
- *Lesson: Gas filled lamps are great for checking day-to-day repeatability but should not be used as a radiometric transfer standard.*

## ◆ *Subsystem Early Consideration*

- *Issue: It is difficult to add-on subsystems (e.g., reference lamps) that are not part of the design considerations from the beginning.*
- *Lesson: Include all subsystems in the early planning.*





# Other Technical Issues (3 of 4)



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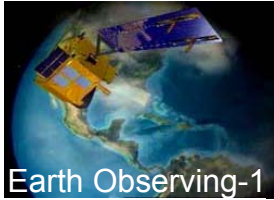
## ◆ On-orbit Data Processing

- *Issue: After launch, the Level 0 data formats changed several times.*
  - *Shifting of pixels and bands*
  - *Left-right reversals*
- *Lesson: The ICD regarding Level 0 processing and the Calibration Pipeline should be completed and frozen before launch.*

## ◆ Schedule

- *Issue: The ALI schedule remained very tight even when it became clear that other parts of the program were slipping.*
  - *Opportunities to avoid overtime and do a more thorough job were missed.*
- *Lesson: Harmonizing all delivery schedules can produce some program benefits.*





# Other Technical Issues (4 of 4)

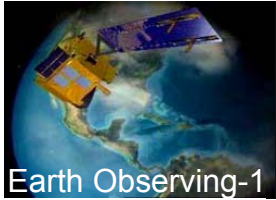


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## ◆ **More Lessons Learned**

- *Insist on thorough documentation of all vendor (subcontractor) tests.*
- *Document the “as-built” characteristics of each part.*
- *Provide a complete photo documentation of the instrument prior to delivery, with close-ups of all critical items.*
- *Comparison of several independent calibration techniques has proved to be extremely valuable both in ground and on-orbit measurements.*
- *Calibration of each detector of a large focal plane is a manageable job but requires thorough preparation of test plans, test instrumentation and associated software to process the large volume of data.*





# Summary



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- ◆ *Many of the lessons learned have a common thread: the tight development schedule and budget require greatly focused mission objectives.*
- ◆ *A highly motivated, dedicated team can overcome the inevitable problems associated with a high-risk technology validation mission and bring about success.*

